STRUCTURE OF THE SPORE WALL IN CERTAIN MIOSPORES BELONGING TO THE SERIES CINGULATI POT. AND KLAUS 1954

by A. H. V. SMITH

ABSTRACT. Miospores of the genera *Densosporites* and *Anulatisporites* are described in which the spore wall consists of two separate membranes. The inner membrane, considered to be the intexine, forms a 'central body' which can be seen in equatorial section of the spore exines in polished surfaces of coal and in specimens isolated from the coal.

THE presence of an inner membrane or 'mesosporium' has been demonstrated in the megaspore *Duosporites congoensis* Høeg, Bose, and Manum 1955 from the *Glossopteris* flora of the Belgian Congo. These authors cite several examples from published work to support their view that a so-called mesosporial membrane is of more common occurrence in spores than has been believed hitherto. The examples they quote relate almost entirely to megaspores but the existence of an homologous membrane has recently been observed in certain miospores not previously recorded as possessing such a membrane.

The miospores concerned belong to the genera *Densosporites* (Berry) Potonié and Kremp 1954, and *Anulatisporites* (Loose) Potonié and Kremp 1954, found in British Carboniferous coals. The inner membranes were first seen when a piece of durainous coal cut parallel to the bedding and containing large numbers of *Densosporites* was polished and examined by reflected light using a low-power oil immersion objective. Subsequently a careful examination of spores isolated from the coal by using fuming nitric acid revealed an occasional specimen in which part of the outer membrane had become severed and lost leaving the inner membrane protruding and intact. Examples of *Densosporites* with an inner membrane showing in this way have been observed in separations made from coals of Lower and Upper Carboniferous age. Spores belonging to the genus *Anulatisporites* do not usually occur in such dense accumulations in the coal as certain species of *Densosporites* and the inner membrane in this genus has so far only been observed in isolated specimens.

The specimens of *Densosporites* exposed in the polished surface of durain (Pl. 20, figs. 1, 2) all show the membrane which can be seen as a thin, undulating, or folded line on the inside of the thickened equatorial zone. In most cases it is continuous but in some specimens it shows short breaks. It may lie close to the equatorial thickened zone or may be shrivelled to a greater or lesser extent, in which case it is well separated from the zone of thickening. The majority of specimens in the block were cut more or less in the equatorial plane and in this plane the membrane appears, at least in the fossil state, to be entirely free of the thick outer coat of the spore. Owing to the preferred orientation of the spores in the plane of section, no indication has been found of the attachment of the membrane to the outer coat at any point. An examination of the spores in polar plane, by preparing sections cut vertical to the bedding of the coal, similarly

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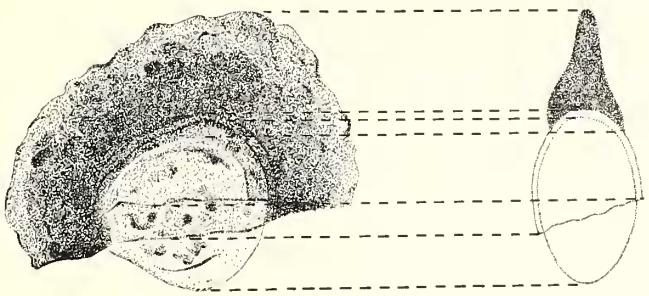
failed to show the manner of attachment due to the extremely compressed state in which the spore exines are preserved in this plane.

In the isolated specimens of *Densosporites* (Pl. 20, figs. 3–7) and *Anulatisporites* (Pl. 20, fig. 8) the thickened outer coat of the spore has in each case broken across, but the inner membrane is intact and protrudes as a distinct 'central body'. The specimen photographed in Fig. 5 shows the break in the outer coat taking a different course on proximal and distal sides of the spore.



TEXT-FIG. 1. A diagrammatic reconstruction, ×1,000, of the specimen of *Densosporites* shown in fig. 5, pl. 20, as the unflattened spore might appear in plan view and polar section.

The photographs of the four species of *Densosporites* show the differentiation of the equatorial zone or cingulum into a thicker, darker inner and a thinner lighter outer region. The sculpturing of the cingulum is also apparent. According to Potonié and Kremp 1954 these features distinguish *Densosporites* from *Anulatisporites* in which the cingulum is without structure and sculpturing.

Among the species of *Densosporites* illustrated in Pl. 20 are two, *D. striatus* (Knox) Butt. and Will. 1958 and *D. loricatus* (Loose) S. W. and B. 1944 in which there is a well-marked differentiation of the cingulum into darker and lighter zones. *D. striatus* (fig. 3) differs from *D. loricatus* (fig. 4) in that the plications which characterize the inner part of the cingulum extend into the outer thinner region. In the specimen of *D. loricatus* the cingulum has fractured in such a way as to show clearly its cuneiform shape in section. The remaining species of *Densosporites* are considered to be *D. spongeosus* Butt. and Will. 1958 (fig. 5) in which the cingulum and central area possess a perforate ornamentation, and *D. sphaerotriangularis* Kosanke 1950 (figs. 6, 7) in which the cingulum is composed of a number of small plicating sheets. The species of *Anulatisporites* (fig. 8) is *A. anulatus* (Loose) Pot. and Kr. 1954.

The reconstruction of the structure of *Densosporites* based on the specimen shown in fig. 5 is given in text-fig. 1. The structure of *Anulatisporites* is essentially the same.

The terminology of the structural elements of which the walls of spores and pollens are composed is confused by the variety of names which have been applied to them by different authors. Potonié (1952) has attempted to establish a set of terms which were originally defined for pollen but which for simplicity he applies to both spores and pollens. He considers that those parts of the spore wall, exine or exospore, which are normally preserved in fossil material, comprise an outer membrane, the exoexine, composed of different structural elements and an inner membrane, the intexine. The

mesosporium being the inner part of the exine is considered to be equivalent to the intexine. The membrane described in this paper is cutinized and may therefore be regarded as constituting part of the exine. It is accordingly equated with the intexine.

The separation of the intexine from the exoexine is considered by Potonié (1934) to take place in the formation of air sacs in such miospore genera as *Endosporites* Wilson and Coe 1940 and *Florinites* Schopf, Wilson, and Bentall 1944. However, the tenuous nature of the 'central body' wall in *Florinites* led Schopf *et al.* (1944) to suggest that it may not be exosporal in origin.

The separation at maturity of the intexine from the exoexine to a greater or lesser extent and its mode of attachment are features of considerable taxonomic importance. The genus *Duosporites* has been established on the basis of the occurrence of a membrane referred to as a mesosporium by Høeg *et al.* detached from the exoexine except in an area on the proximal side of the megaspore (loc. cit.). In the absence of this feature these spores would be considered as a species of *Laevigatisporites* (Ibr.) Pot. and Kremp 1954. Similarly certain large spores of Lower Cretaceous age possessing a prominent neck have been placed in the genus *Pyrobolospora* Hughes 1955 to distinguish them from spores belonging to the genus *Lageniculа* (Bennie and Kidston) Pot. and Kremp 1954 which they superficially resemble but from which they differ in the separation of the exoexine from the intexine below the neck.

Recently a miospore genus *Vallatisporites* Hacquebard 1957 has been described, which is reported to resemble *Densosporites* in the construction of the equatorial portion but is said to differ from it in possessing a well-defined central body. The latter is separated from the equatorial portion by a distinct groove or rampart-like area from which the name *Vallatisporites* is derived. The existence of a central body would not be sufficient justification for establishing a new genus since it can reasonably be assumed that all species of *Densosporites* possess the structure which has been demonstrated for four species. However, the presence of the groove, which permits the recognition of the central body in the undamaged spore, suggests that the cingulum does not clasp the central body in the manner described by Potonié and Kremp (1954) for *Densosporites*. For this reason the genus *Vallatisporites* may be considered valid for spores in which the body is separated from the cingulum by a groove in the manner described by Hacquebard.

In miospores possessing air sacs, the mode of attachment of the 'central body' to

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EXPLANATION OF PLATE 20

Fig. 1. Durain from Silkstone coal. Section parallel to the bedding, photographed by reflected light using oil immersion objective ×400. The double membrane constituting the spore walls of the miospores of *Densosporites* can be seen in those specimens cut more or less in their equatorial plane.

Fig. 2. Part of the field of fig. 1 ×1,000.

Figs. 3–8. *Densosporites spp.* and *Anulatisporites sp.* in which part of the outer membrane of the spore wall has broken away exposing the inner membrane or 'central body'. Transmitted light ×750.

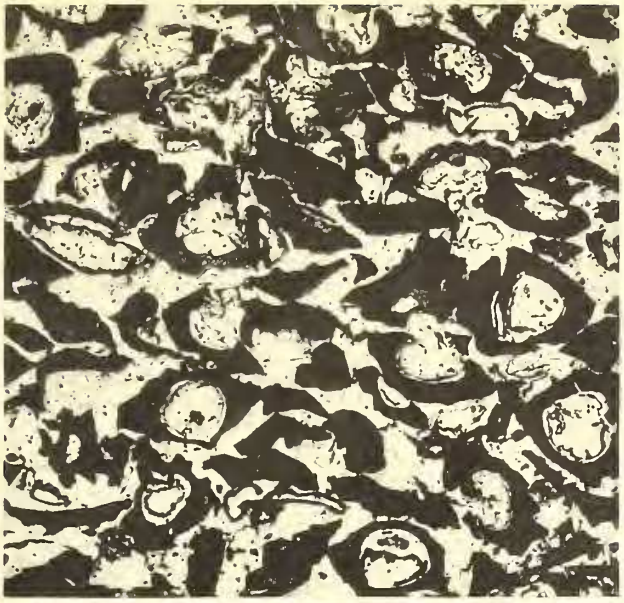
Fig. 3. *D. striatus* (Knox) Butt. and Will. From Silkstone coal (Lower Coal Measures, Yorkshire).

Fig. 4. *D. loricatus* (Loose) S.W. and B. From Upper leaf of Flint coal (Middle Coal Measures, Shropshire).

Fig. 5. *D. spongeosus* Butt. and Will. From Chapelgreen coal (Upper Limestone Group of Scotland).

Figs. 6, 7. *D. sphaerotriangularis* Kos. From 'Branch' band Silkstone coal (Lower Coal Measures, Yorkshire).

Fig. 8. *A. anulatus* (Loose) Pot. and Kr. From Ganister Clay coal (Lower Coal Measures, Durham).



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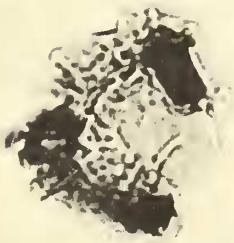

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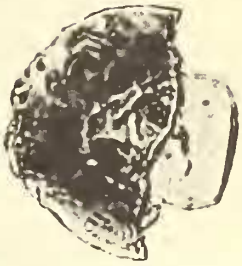

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SMITH, Carboniferous spores